Bellcomm

955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

date: September 24, 1971

to: Distribution

B71 09020

from: T. H. Crowe

subject: Effect of Operating M509 and T020 on the Cluster Atmosphere - Case 620

ABSTRACT

The problem of maintaining the cluster atmosphere within specification limits while operating Experiment M509 is discussed. Operation of M509 will cause the total pressure of the atmosphere and the partial pressure of O_2 to fall outside specification limits unless some control of the atmosphere is done manually.

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MEMORANDUM FOR FILE

The purpose of this paper is to discuss the problem of maintaining cluster atmosphere control while operating Experiments M509 and T020 and some of the alternatives being considered to solve the problem.

Description of the System

Figure 1 is a schematic of the atmosphere control system. Six O_2 tanks and six N_2 tanks filled to 3000 psi provide the source of gases for the atmosphere. These tanks provide 4930 lbs. of usable O_2 and 1320 lbs. of usable N_2. The requirements, assuming specification leak rates, are 4140 lbs. and 924 lbs. of O_2 and N_2, respectively.

The six O_2 tanks are manifolded and O_2 is routed to redundant 120 psi pressure regulators and from there to various parts of the cluster including the O_2 N_2 two-gas control system. Four of the N_2 tanks are manifolded and N_2 is routed to redundant 150 psi regulator valves and from there to various parts of the cluster including the O_2 N_2 two-gas control system. The remaining pair of N_2 tanks can either be isolated to provide topping off of the M509 and T020 N_2 bottles or can be valved into the N_2 manifold.

The O_2 N_2 two-gas control system consists of three O_2 partial pressure sensors, a solenoid controlled N_2 flow valve, redundant cabin pressure regulators and control electronics. Any one of the three O_2 partial pressure sensors

can be used for one or both functions of providing the signal to control the N_2 flow valve or providing the signal for the TM system. Provision is also made for flowing pure O_2 or N_2 across the sensors for calibration. The control electronics associated with the O_2 partial pressure sensors are set at a nominal 3.7 psia with a dead band of ±.1 psia. However, available data indicate that the normal operating range is 3.58 psia to 3.85 psia. Thus, if the output of the O_2 partial pressure sensor reading is 3.85 psia or higher the N_2 flow valve is opened. This closes the O_2 check valves and N_2 is supplied to the cabin pressure regulators. If the reading is 3.58 psia or less, the N_2 flow vlave is closed and O_2 is supplied to the cabin pressure regulators. The accuracy of the sensors and associated electronics and the system response are not well known at this time but is thought to be such that O_2 partial pressure can barely be maintained within specification limits, 3.7 ± 0.2 psia.

The cabin pressure regulators maintain the total pressure at a nominal 5 psia ±.2 psia. The regulators are of the demand type and will attempt to flow gas at the rate it is used. The flow characteristics of the regulators are given in Figure 2.

The system is also connected into the caution and warning system so that an alarm is initiated if the O_2 partial pressure drops below a nominal 3.05 psia, the total pressure drops to a range of 4.5 to 4.7 psia or if the total pressure is decaying at a rate in excess of 0.1 psi/min.

The cluster is also equipped with vent valves that crack open if the total pressure exceeds 5.5 psia and will open fully to prevent the total pressure from exceeding 6 psia.

Using specification values for leak rate the total demand for gases under normal operation is about 23.5 lbs. per day. This consists of six lbs. of O_2 for metabolic use, 14 lbs O_2 and N_2 for leakage and 3.5 lbs. O_2 and N_2 for operation of the molecular sieves.

Operation of the System

If one assumes that the cluster has been pressurized, normally done by ground command, that the switches are positioned for normal automatic control of the atmosphere, that leakage rate is at specification value and that the initial O_2 partial pressure is 3.7 psia and the initial total pressure is 4.9 psia. The operation of the system is as follows.

At the nominal leakage rate the cabin pressure regulators are flowing either O_2 or N_2 at the rate of about .98 lbs. per hour. To initialize the system one must assume which gas is flowing. If one assumes that O_2 is flowing then this continues until the O_2 partial pressure reaches 3.85 psia, then N_2 flows until the partial pressure of O_2 reaches 3.58 psia. An approximation of the cylic operation of the system is illustrated in Figure 3.

M509 and T020

M509 and T020 are both astronaut maneuvering experiments utilizing gaseous N_2 as propellant. Current planning for accomplishment of the objectives of the experiment are to conduct four runs for M509 during the SL-1/2 mission, one of which is in a pressurized space suit, and eight runs on the SL-3 mission, two of which are in a pressurized space suit. Four T020 runs are scheduled for SL-3, two of which are in a pressurized suit. Runs last for about one hour, and during each M509 run about 20 lbs. of N_2 is released into the cabin. About 10 lbs. of N_2 is released during T020 run. In addition during suited runs, about 12.3 lbs. of O_2 is released into the cabin. M509 runs are currently scheduled on days 4, 8, 16, and 20 of the SL-1/2 mission and on days 8, 13, 17, 22, 25, 31, 35, and 41 of the SL-3 mission. T020 is scheduled for days 45, 48, 51, and 54 of the SL-3 mission. An approximation of the effect of these runs on cabin atmosphere pressure for the SL-1/2 mission is illustrated in Figure 4.

Several observations can be made from this figure. The O_2 partial pressure varies from 3.4 psia to 3.98 psia, considerably outside the specification limits. This does not take into account the inaccuracies of the O_2 partial pressure

sensors. The total pressure varies from 4.89 psia to 5.5 psia, resulting in the vent valves opening once. Similiar results are obtained when one calculates the pressure profiles for the SL-3 mission.

Another way to get a feel for the problem is to look at N_2 requirements. At specification leak rate the total N_2 makeup requirement for the SL-1/2 mission is 116 lbs.; four runs of M509 introduce 80 lbs. of N_2 into the atmosphere.

MSC has done a series of studies on the problem and determined that lower leak rates make the problem worse and that with a leak rate of about 125% the problem is all but eliminated. In order to eliminate the problem with a 50% leak rate they consider the following steps necessary.

1. Initialize the cabin pressure at O_2 partial pressure 3.9 psia and N_2 partial pressure 1.1 psia.
2. Inhibit automatic N_2 makeup for entire mission.
3. Reschedule the experiment runs at longer time intervals, including some runs on SL-4.
4. Shutoff all makeup gases approximately 18 hours before suited runs, or manually vent the cabin atmosphere just before suited runs.

The problem is being worked by the Flight Operations Planning group and alternative solutions will probably be forwarded for management consideration within two or three months.

T. H. Crowe

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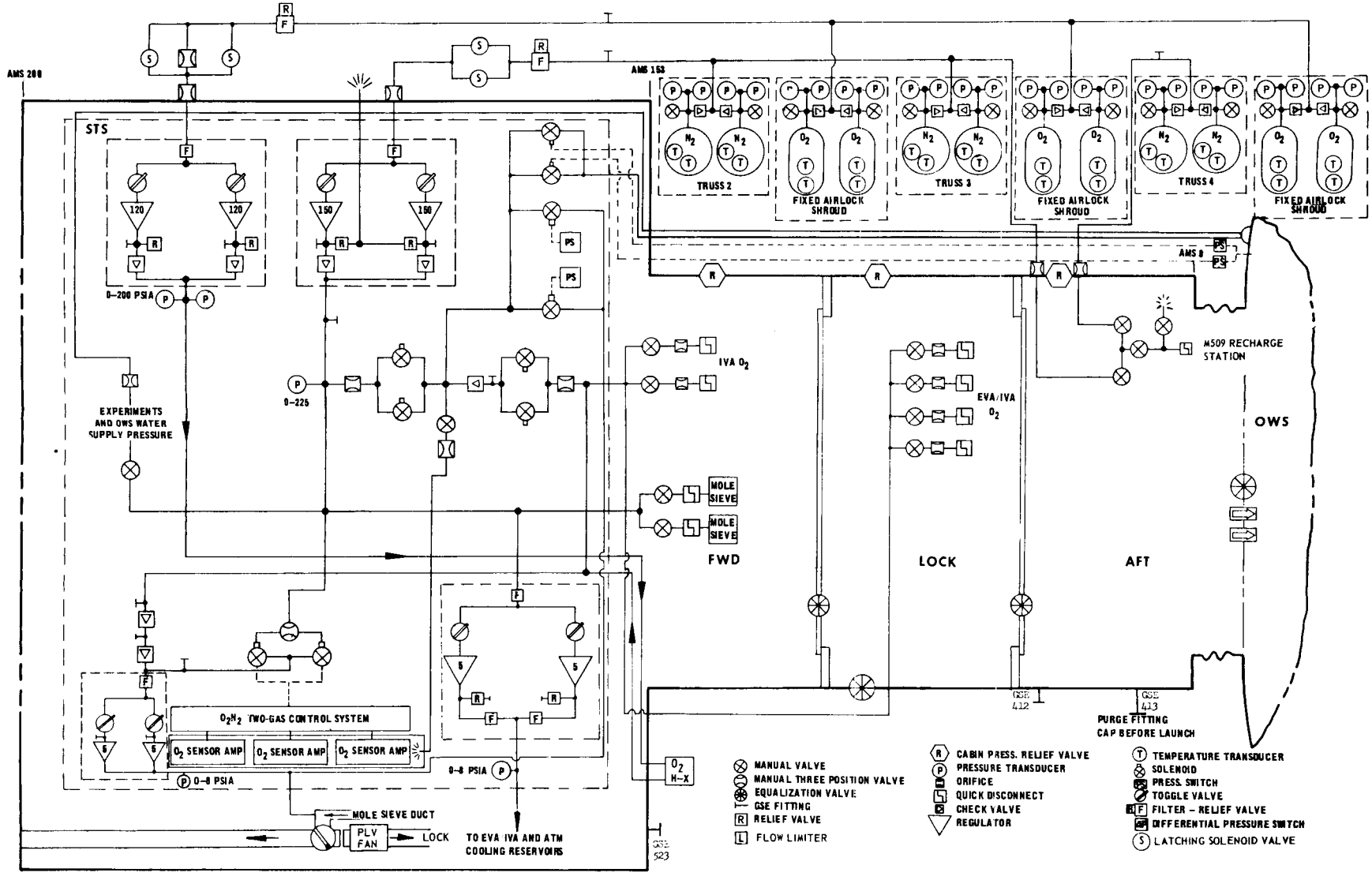

FIGURE 1 - GAS SYSTEM

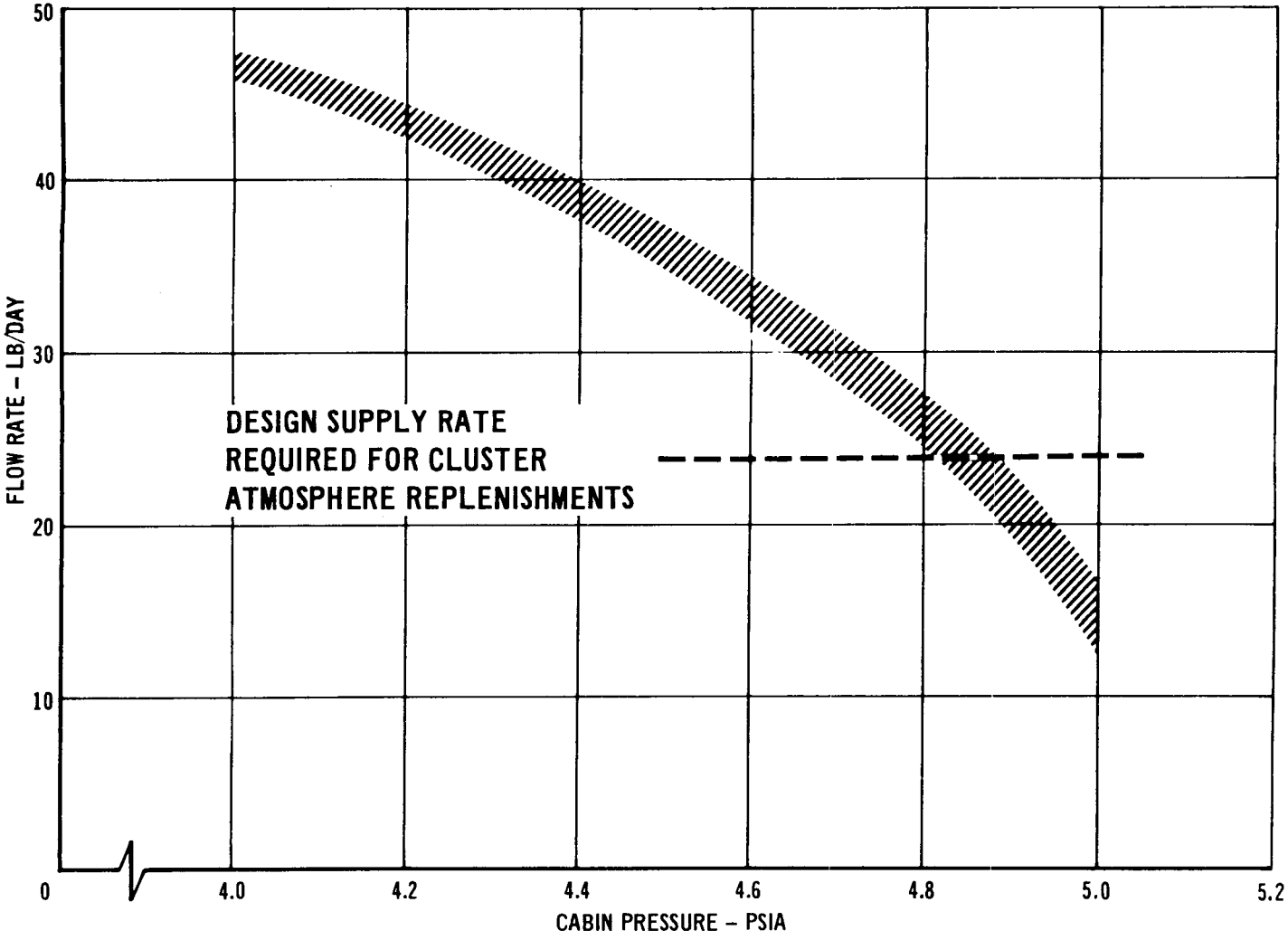

FIGURE 2 - CABIN PRESSURE REGULATOR FLOW RATE CHARACTERISTICS

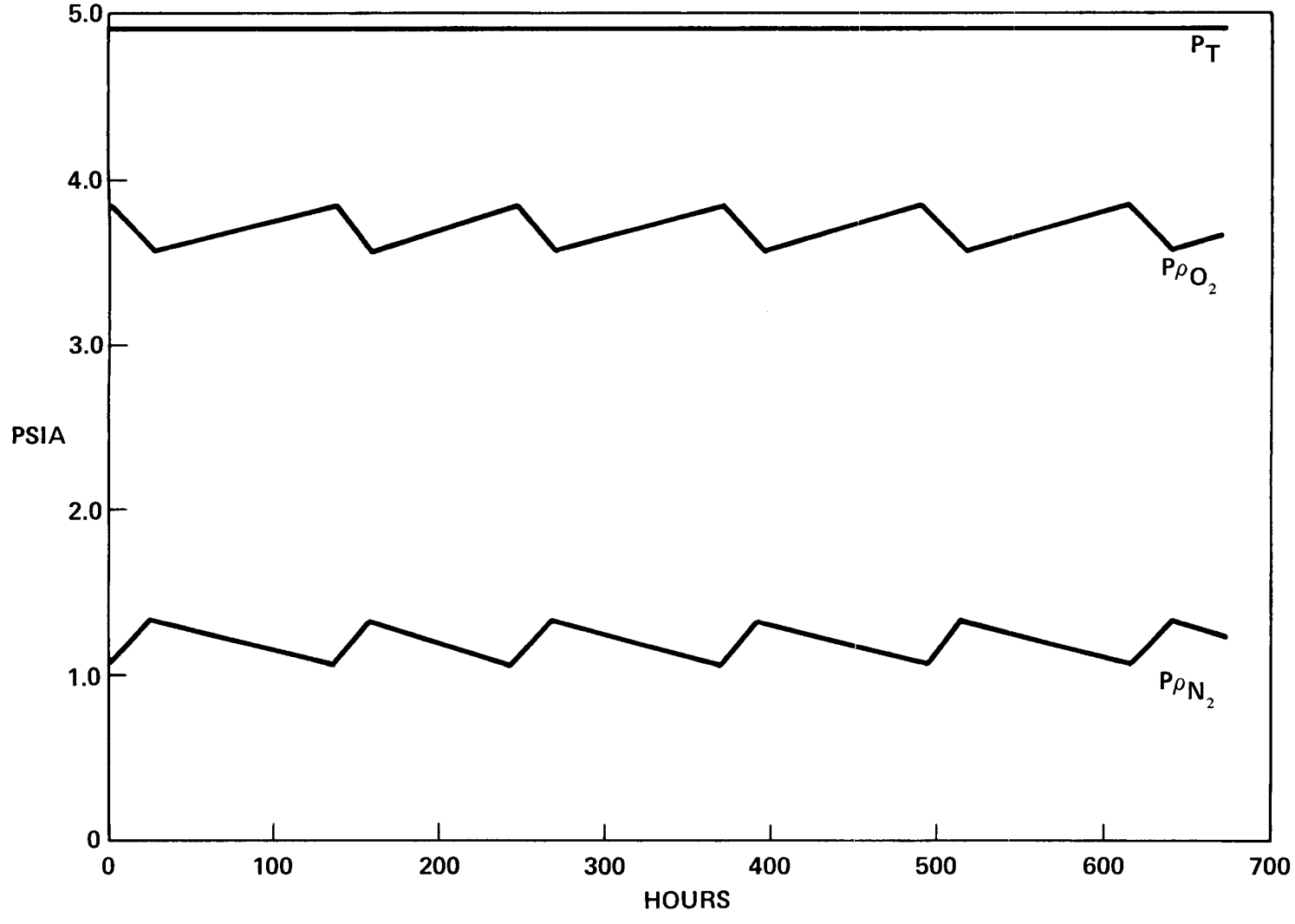

FIGURE 3 - CABIN PRESSURE — 100% LEAK RATE

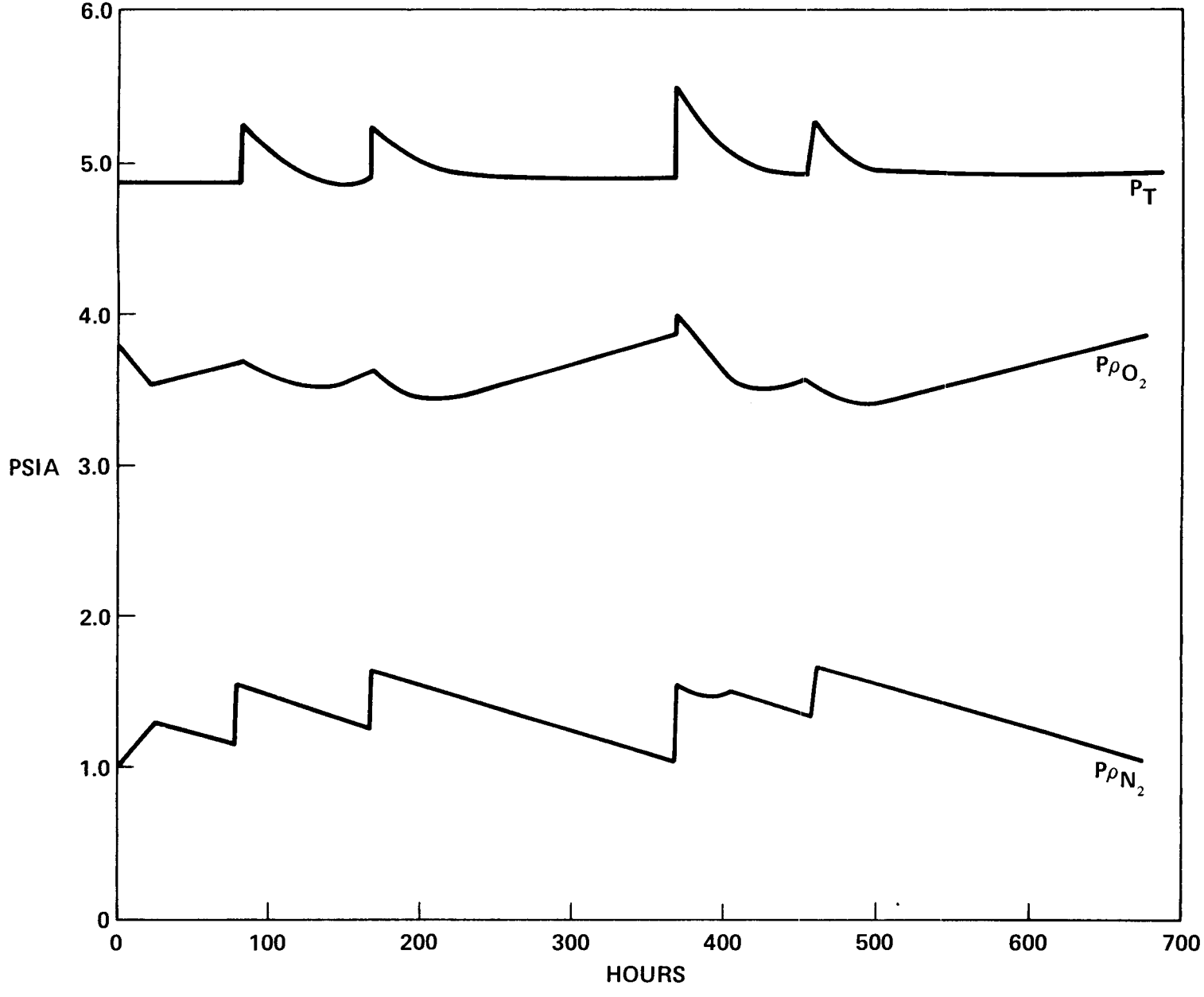

FIGURE 4 - SL1/2 CABIN PRESSURE – 100% LEAK RATE
OPERATING M509